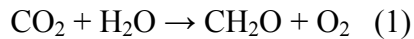


Carbon Dioxide, Coral Reefs and Climate Change

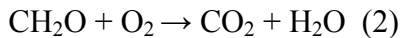
Two biological processes drive the carbon cycle on coral reefs: 1) Organic carbon metabolism (photosynthetic fixation and respiration) and 2) Inorganic carbon metabolism (precipitation and dissolution of calcium carbonate). The simplified equations for these processes are listed below.

Organic carbon metabolism

Photosynthesis

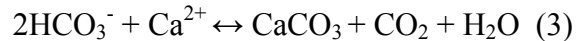


Respiration

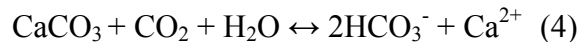


Inorganic Carbon metabolism

Calcification

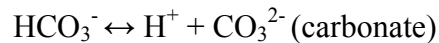
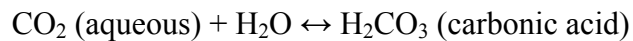
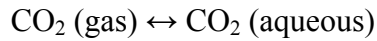


Dissolution of carbonate



Carbon dioxide (CO₂) concentrations, a greenhouse gas found in the Earth's atmosphere, have increased since pre-industrial times primarily due to the combustion of fossil fuels. Based on realistic scenarios of future emissions this trend will continue and atmospheric CO₂ concentrations are expected to reach double pre-industrial levels by 2065 (Houghton et al. 1996). Elevations in atmospheric CO₂ are predicted to cause an increase in the partial pressure of CO₂ (P_{CO₂}) in the surface ocean, thus causing seawater to become more acidic (Broecker et al. 1979). The rationale behind this is due to the fact

atmospheric CO₂ is in equilibrium with CO₂ in the oceans, thus any increase in atmospheric CO₂ will result in an increase in seawater CO₂. The reactions for this process are given below.



The interaction of CO₂ in seawater with calcium carbonate ($\text{CO}_2 + \text{H}_2\text{O} + \text{CaCO}_3 \leftrightarrow 2\text{HCO}_3^- + \text{Ca}^{2+}$) shows how an addition of CO₂ enhances CaCO₃ dissolution and removal of CO₂ enhances its precipitation. For example, the addition of more CO₂ on the left side of the equation pushes the reaction to the right favoring dissolution of CaCO₃ to balance the reaction, and vice versa. Based on these assumptions laboratory studies have shown that a doubling in the concentrations of CO₂ (aqueous) can cause a 20-54% reduction in the calcification of corals (Langdon et al. 2000; Leclercq et al. 2000; Leclercq et al. 2002; Langdon et al. 2003).

Specific concern is raised in regards to the persistence of reef structures as carbonate budget studies have demonstrated that constructive (calcification) and destructive (bioerosion, mechanical erosion) processes are closely balanced on many reefs with net reef accumulation barely ahead of net reef loss (Schoffin et al. 1980; Glynn 1988). Thus, even small-scale shifts reducing coral calcification associated with increases in CO₂ concentrations may result in net reef loss.

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